# ARM2'd to the Teeth
What's new with ARM2?

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Agenda

- Overview of ARM and the "old" ARM2

- ARM2 in the Proposed Appendix W Revisions

- Comparison of NO_X to NO_2 Tier 2 and Tier 3 Conversion Options

- Benefits of the new ARM2

- Issues around the new ARM2

- How about Tier 3?

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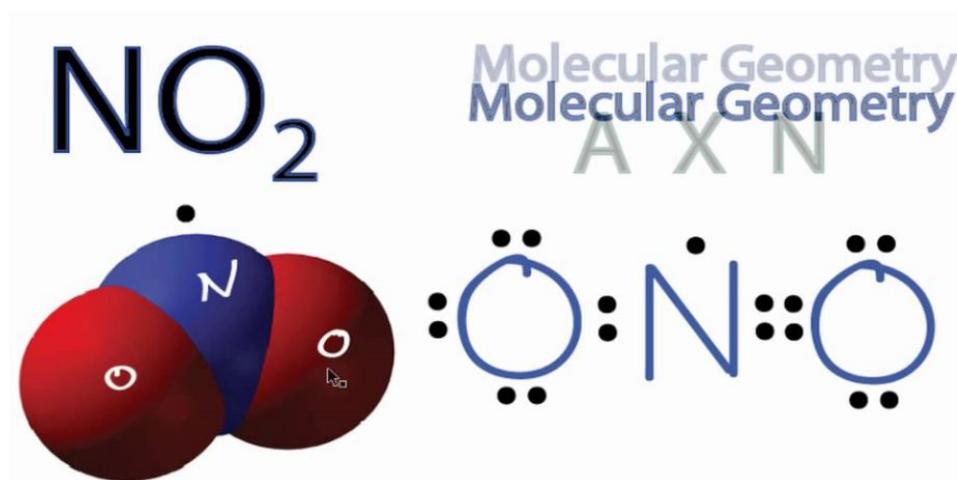
Converting NO_X to NO_2 in AERMOD

- EPA allows three tiers of accounting for NO_X to NO_2 conversion:

- Tier 1: Full conversion of NO_X to NO_2.

- Tier 2: Ambient Ratio Method based on analysis of ambient monitoring data. (ARM and ARM2)

- Tier 3: Refinement based on the oxidation of NO by O_3 to NO_2 (OLM and PVMRM)

$$NO + O_3 = NO_2 + O_2$$

Where did ARM come from anyway??

- Originally developed outside the realm of air dispersion modeling, but when Annual NO_2 modeling came around, the 90th percentile of average annual NO_2/NO_X monitoring data was used to establish a default ratio of 0.75.

- In March 2011, EPA addressed the new 1-hour NO_2 NAAQS and recommended a conservative ARM ratio of 0.8 for 1-hour NO_2, with no approval needed.
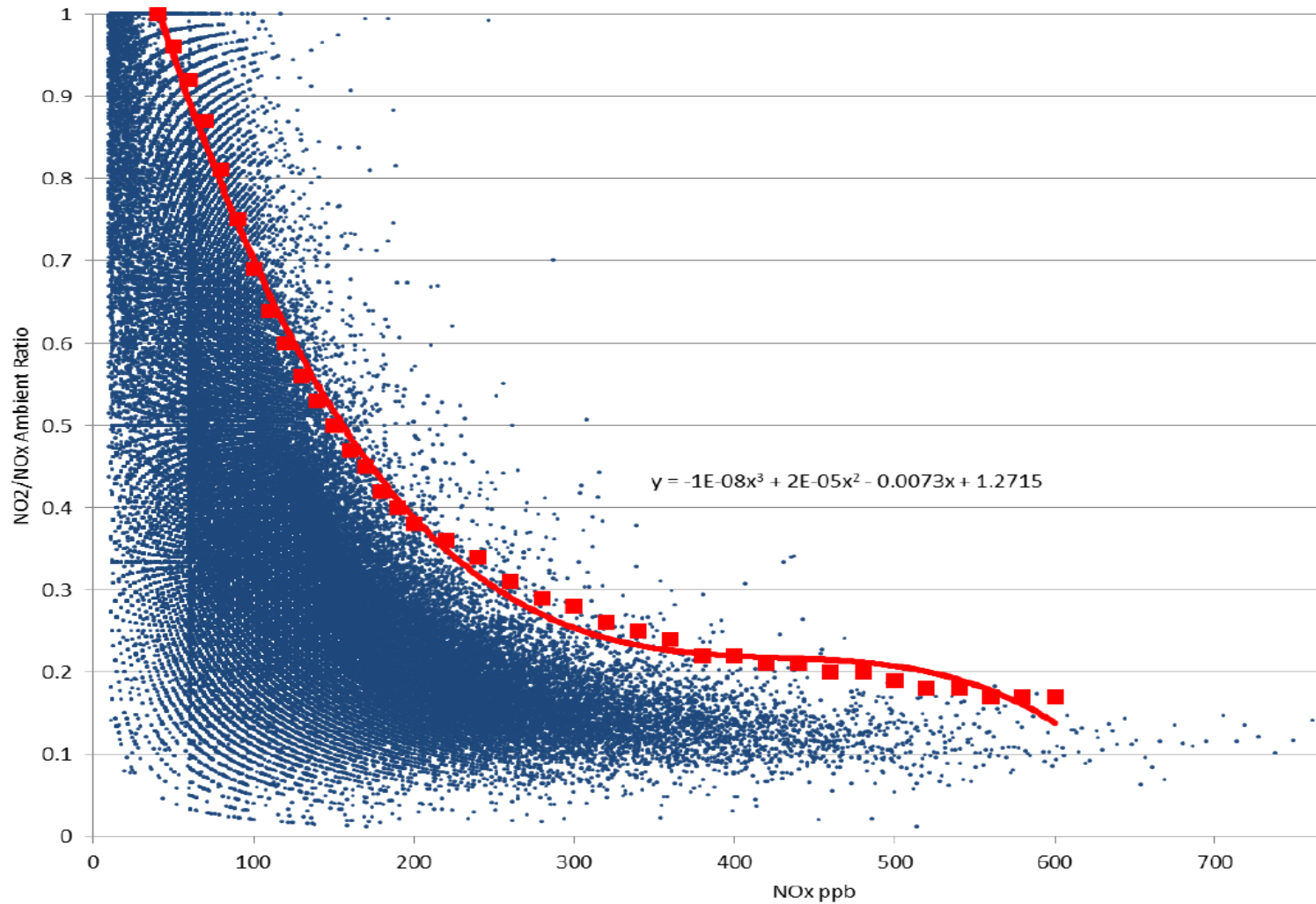
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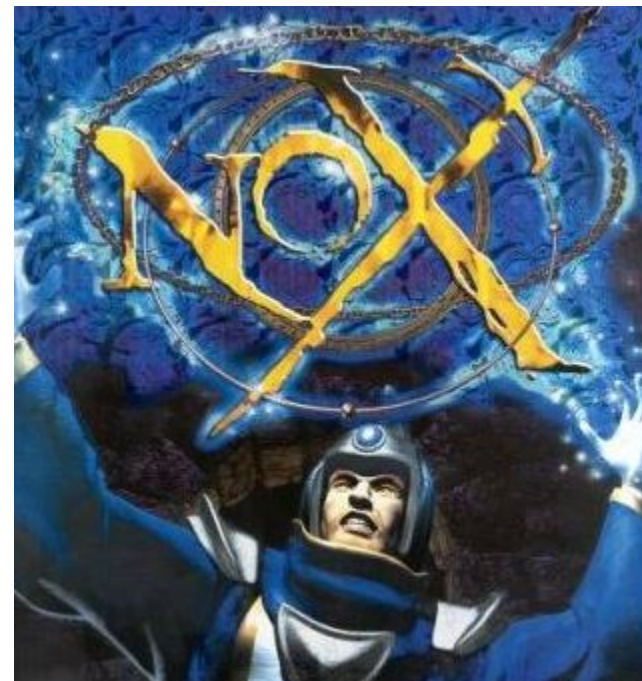
Enter ARM2

- Podrez (2013), Developed for API.

- Studied ambient NO_2/NO_X ratios from 580 ambient monitors in US and elsewhere.

- Developed a 6th order polynomial curve of NO_2/NO_X ratios based on ambient NO_X concentrations.

- Designed as a simpler alternative to the Tier 3 refinements OLM and PVMRM as opposed to an alternative to ARM:

  o No additional inputs

  o Runs faster than Tier 3 refinements

  o No case by case approval by regulators and easier to review means less resources on both ends.

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The ARM2 Curve

$$y = -1E\text{-}08x^3 + 2E\text{-}05x^2 - 0.0073x + 1.2715$$

From: Ambient Ratio Method Version 2 (ARM2) for use with
AERMOD for 1-hr NO2 Modeling (Podrez 2013)

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ARM2 For AERMOD

- Added as of AERMOD v.12345 as Beta option.

- Upper end of curve limited to NO_2/NO_X ratio of 0.9 and lower end of 0.2.

- Required Case By Case approval for use in permit modeling.

- EPA Webinar around release of AERMOD v.14134 on August 12, 2014 recommended if Tier 1 results were less than 150-200 ppb. If over threshold, demonstrate ISR < 0.2 or use alternate minimum ratio.

- Higher thresholds were recommended if background NO_2 was "higher", and caution recommended for particularly high background ozone levels, but no guidance as to what constituted high NO_2 or Ozone background.
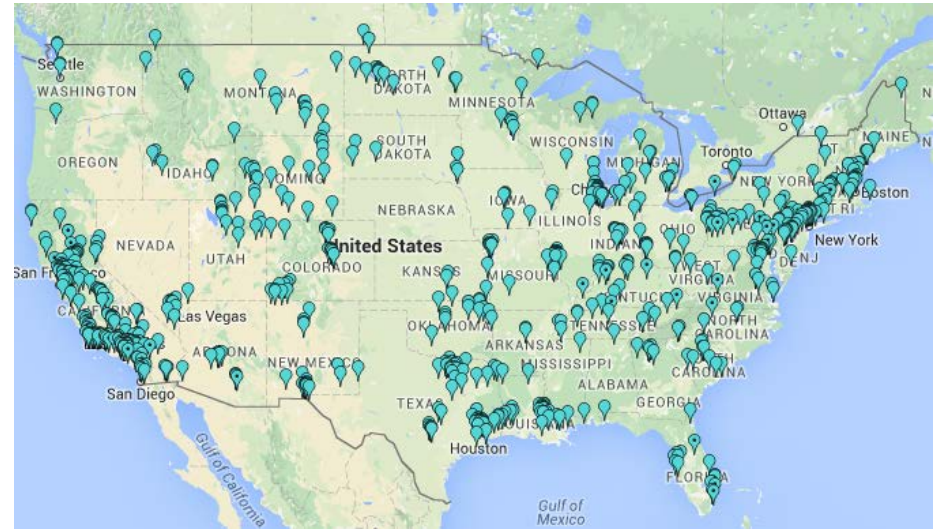
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"Old" ARM2 vs. Tier 3: OLM and PVMRM

Sensitivity modeling based on 2004 MACTEC Report for single and cumulative source scenarios:
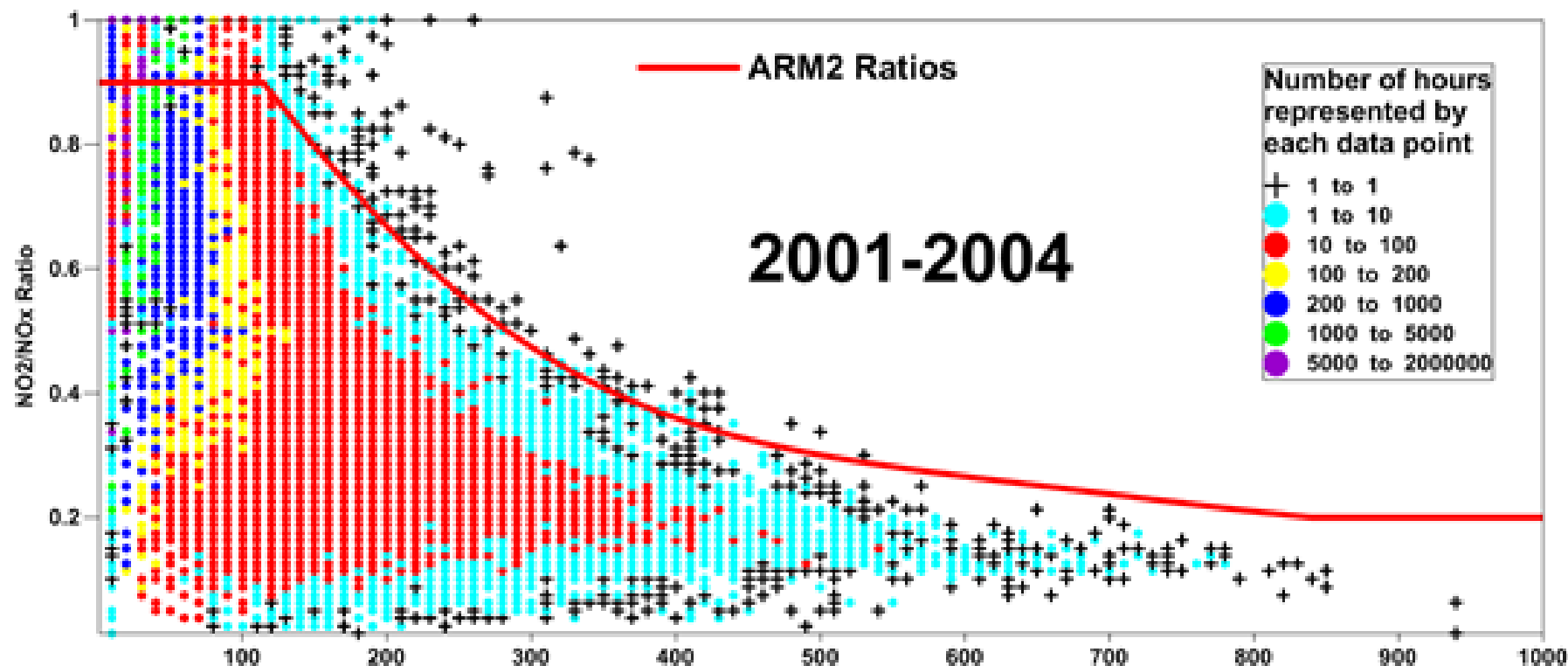
- At very low concentrations (below 20 $\mu g/m^3$), ARM2, OLM, and PVMRM all predict NO_2/NO_X ratios around 0.9.

- At higher impacts (> 300 $\mu g/m^3$), all methods had NO_2/NO_X ratios between 0.2 and 0.4, with ARM2 consistently the highest of the 3.

- At some very high impacts, PVMRM had ratios higher than ARM2, likely because of a formulation error in PVMRM that had previously been identified and is being addressed in the proposed PVMRM2.
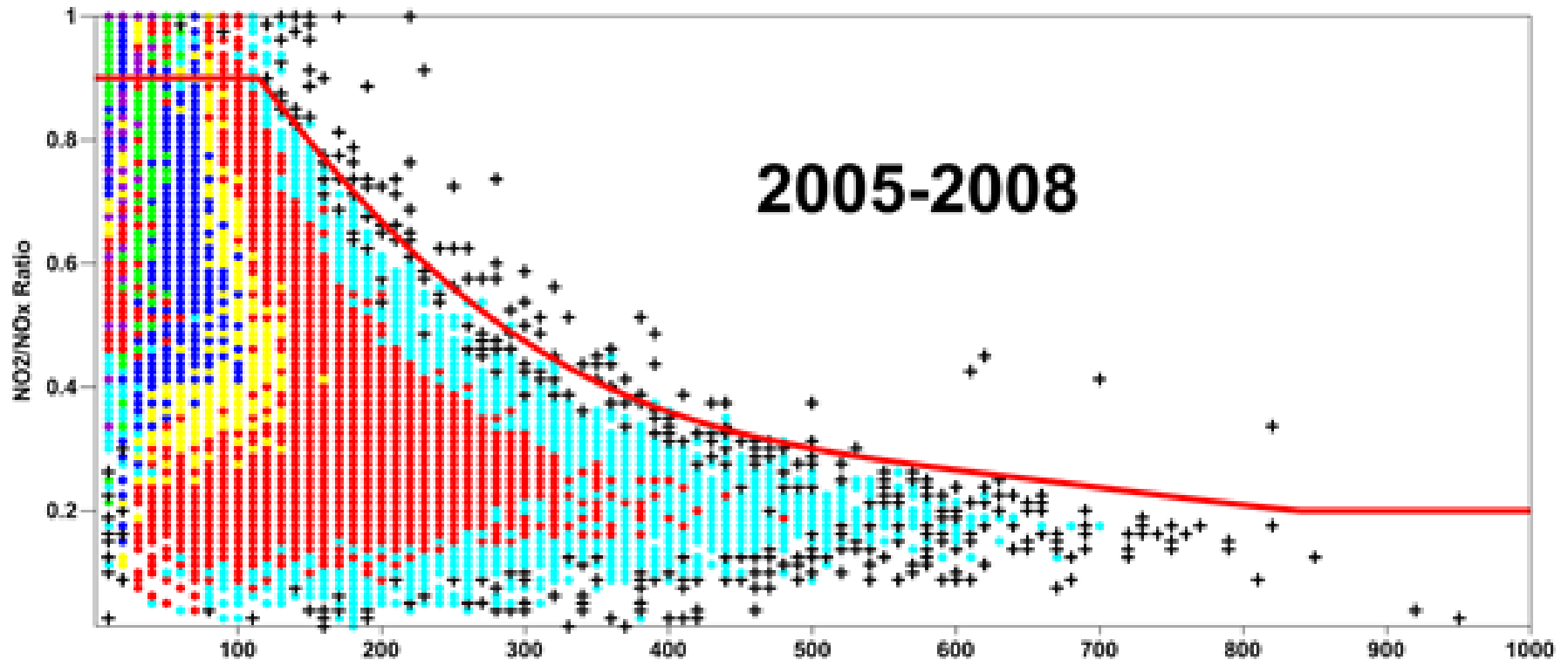
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Updating The ARM2 Development Report

- Analysis performed seeking approval for ARM2 use in permit modeling.

- All monitors in the US were reviewed for period of 2001-2012. Focus was on monitors similar to project site so urban monitors were not considered. Resulting data set had more than 4 million data points, with increasing observations by year (274,000 in 2001, 609,000 in 2012).

- Ultimate Result ARM2 approved after 1 year and 3 days of discussion and political wrangling with a minimum NO_2/NO_X ratio of 0.54.
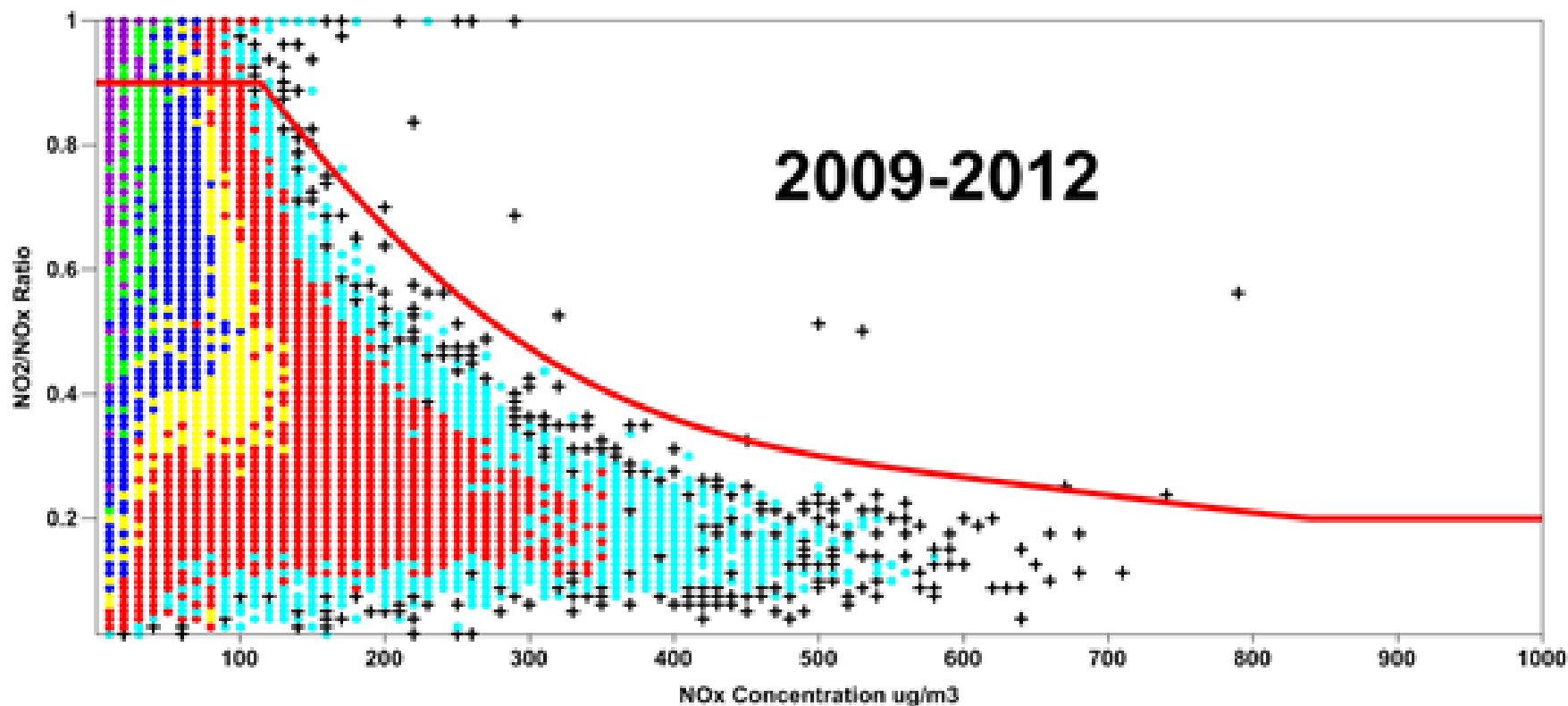
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Observed NO_2/NO_X Ratios 2001-2004

Observed NO_2/NO_X Ratios 2005-2008

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Observed NO$_2$/NO$_X$ Ratios 2009-2012

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ARM2 in Proposed Appendix W Revisions

- Proposed Revisions to Appendix W, posted July 29th, 2015 would:

- Replace the old ARM with a modified version of ARM2 as recommended Tier 2 method.

- The "New ARM2" will use the same ARM2 curve, but have a minimum default NO_2/NO_X of 0.5 instead of 0.2, tied to default value for OLM/PVMRM. Approval required for lower minimum

NO_2/NO_x In-Stack Ratio (ISR) Database

ISR	# of Entries	% of total
> 0.5	105	4.5%
> 0.2	531	22.9%
< 0.2	2323	76.8%

http://www.epa.gov/scram001/no2_isr_database.htm

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ARM vs. ARM2(0.2) vs. ARM2(0.5)

- Consider the concept of "compliance ranges": the range in which a NO_X concentration > the 1-hour NO_2 Standard (188 $\mu g/m^3$), refines to a NO_2 concentration < the standard:

Tier 2 Method	Compliance Range ($\mu g/m^3$)
ARM	189-235
Proposed ARM2	189-376
Current ARM2	189-940

The proposed ARM2 with minimum 0.5 NO_2/NO_X ratio increases compliance range over ARM from 235 $\mu g/m^3$ to 376 $\mu g/m^3$ but has a much smaller compliance range than ARM2 had before proposed revisions.

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ARM2'd and Dangerous: The Issues

- In some fairly important cases, ARM2 provides higher ratios than ARM did!

- Old ARM NO_2/NO_X Ratio was 0.8. ARM2 Ratio exceeds 0.8 when NO_X is less than 149 $\mu g/m^3$.

- Potential Issue when SIL modeling: With ARM, a NO_X concentration of 9.4 resulted in NO_2 = SIL of 7.5 $\mu g/m^3$.

- With ARM2, a NO_X concentration of 8.4 results in a NO_2 concentration of 7.6 $\mu g/m^3$. Over the SIL!!

- Lower minimum ratio can be requested on case by case basis, but no guidance on how this will be established when modeling multiple sources. Potentially more difficult than gaining approval for ISR in Tier 3.

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Proposed Changes to Tier 3 Methods

- OLM and PVMRM to become accepted Tier 3 screening methods rather than alternate models requiring justification. Still would have to, on a case by case basis:
  - Justify choice of OLM vs. PVMRM
    - PVMRM generally better for relatively isolated, elevated sources, like tall stacks. Not recommended for area or line sources, low-level releases or for groups of sources with moderate distances between them.
    - OLM, with the OLMGROUP ALL option, is recommended for all other cases.
  - Justify the in-stack ratios for all sources unless using the default of 0.5.

- PVMRM2 to replace PVMRM:
  - Corrects formulation that overestimates NO_2 concentrations in stable conditions.
  - Modifications to account for plume volume in cases where meander component causes upwind of the source.
  - Other corrections to formula to calculate plume volumes.

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Conclusions

- ARM2 was originally conceived as a simpler alternative to a Tier 3 OLM/PVMRM analysis with slightly more conservative results. No longer the case.

- ARM2 has a greater compliance range than ARM did but less than ARM2 with the Beta 0.2 minimum NO_2/NO_X ratio did.

- In some cases, ARM provides more refinement than ARM2, including concentrations close to the SIL (7.5 $\mu g/m^3$).

- How does one justify a lower minimum NO_2/NO_X ratio in the case of a site with a variety of sources and operational conditions?

- Ambient NO_2/NO_X curve appears to be decreasing. Need for periodic review?

- Comments are due by **October 27th, 2015**, Get 'em in!! (we'll help!)

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Questions? / Contact Information
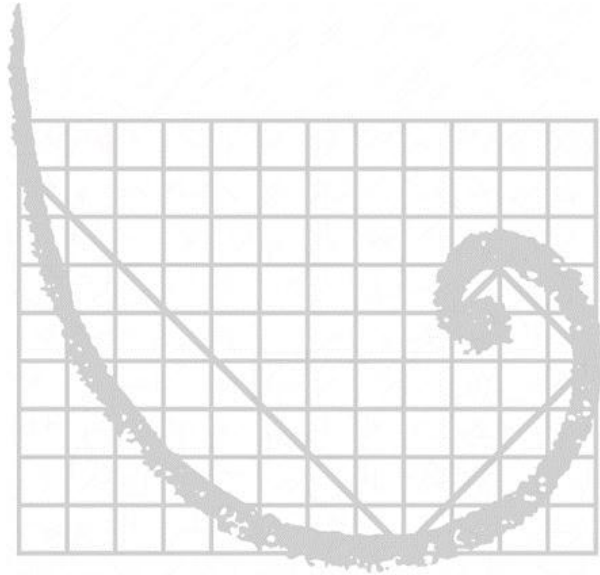
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